Maximizing Value with Industrial AI

Dr. Colin Parris | Corporate Officer and Vice President,
GE Software and AI Research, GE Research

Industry value: Drivers and dynamics

KEEP 300K PEOPLE IN THE SKY/HR.

1/3 OF THE WORLD ELECTRICITY

16 K SCANS PER MINUTE

DRIVERS

1 **INCREASED PRODUCTIVITY**

2 **FASTER GROWTH**

3 **RISK-MANAGED ADAPTABILITY**

4 **IMPROVED SAFETY**

DYNAMICS

Deeper customer engagement
E.g. Emirates, ENEL

Blurring markets and government influences
E.g. Bezos, Musk, US/China

SPACEX

TESLA

THE BORING COMPANY

Digital – ↑ capabilities @ lower cost
E.g. Online, tele, autonomous

Creating value: AI integration in business processes

Providing insights that continuously deliver better outcomes

CONSUMER

$634.69B – 2018 Revenues

Age 25-34

Female

Income < $70K

First child, 5-10 months

Parents live ~ 600 miles

Spends $1.2K/month online

MODEL OF 1

P&L OF 1

PLATFORM FOR ALL

INDUSTRIAL

Flying in North America

Flies 80% in Pacific NW

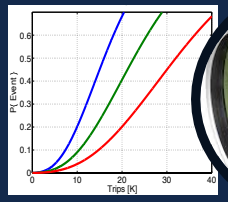
2.6 Service Years

Temp. T49 delta < 10º F

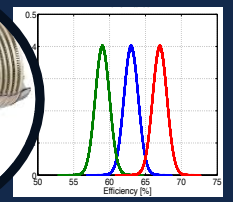
Last inspection found distress ranking < 2

Due for overhaul in 7.1 months

Individual **LIFE**



Individual **PERF.**



Extracting value: Digital Twin | A personalized, living, learning, model

Physical Asset

Knowledge
Design, Manufacturing
Service, Operations

Physics/ Domain Knowledge + **Data/ Machine Learning**

Digital Twin

INSIGHTS
Asset – Remaining Part Life
Operations – efficiency
(Thrust, fuel)

Data

Delivery – Value actions

ADVISORS, PROCESS, CONTROLS

AI-BASED CONTINUAL LEARNING

DESIGN FEEDBACK

CONTINUOUSLY IMPROVING BUSINESS OUTCOMES

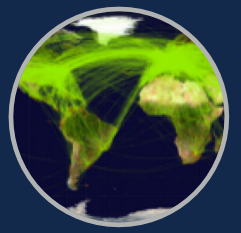
Delivering value: Aviation customer outcomes

Knowledge

+

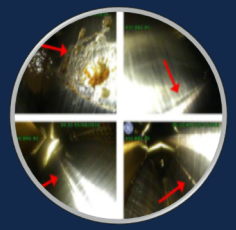
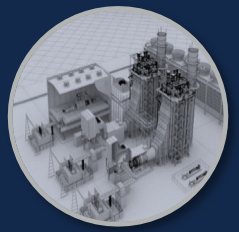
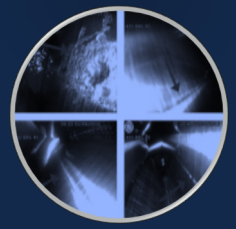
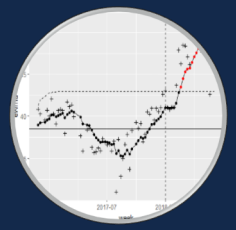
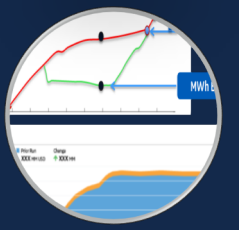
Data

DELIVERY VALUE

SUFFICIENT EARLY WARNING	CONTINUOUS PREDICTION	DYNAMIC OPTIMIZATION
		
Comp pressure, temperature, EGT	S1 Blade; TB coating, env. parameters	Fleet, routes, env. data, CDM
		 
Predict probability of failure	S1 Blade cumulative damage	Scenario analysis and optimization
		
Predict compressor issues **>30 days**	Optimized inspection schedule **($91 MM`17, 56% planed outage reduction)**	Fleet optimization **($45MM`17)**

Delivering value: Energy customer outcomes

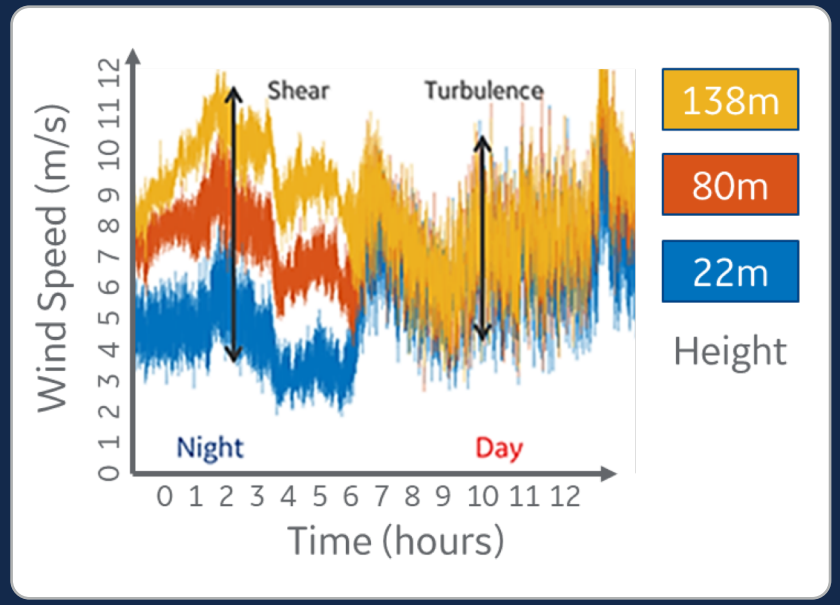
Knowledge + Data ↓ DELIVERY VALUE

SUFFICIENT EARLY WARNING	CONTINUOUS PREDICTION	DYNAMIC OPTIMIZATION
		
Gearbox, generator, nacelle, hub	Battery temp, volts current, # of cycles	Turbine MW, Exhaust temp & press
		
Probability of failure	Cumulative damage, remaining useful life	Part life, firing temp, plant efficiency
		
$4,600 per turbine/year by avoiding unplanned downtime	Up to **15%** extended battery life, reservoir sales and warranty support	Dispatch optimizer (MW bank) - **$1MM - $3MM** additional profit/year

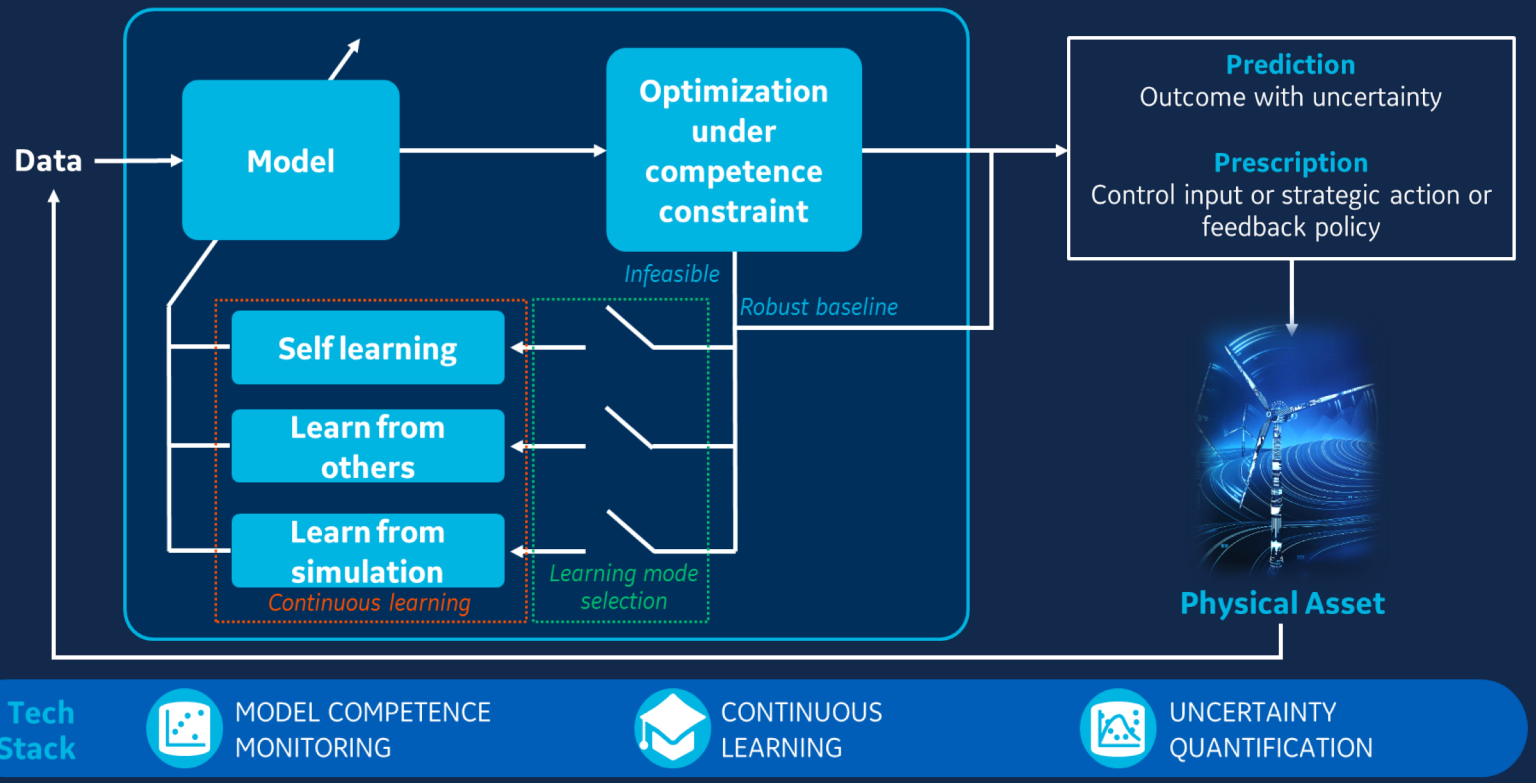
GE 2016-2017: 1.2+ MILLIONS TWINS; $580+ M VALUE

Protecting value: Humble AI

Use Humble AI to accelerate adoption while reducing business risk



Humble AI Architecture



+1% AEP

Enhancing value: Continuous learning and improvement

Engine

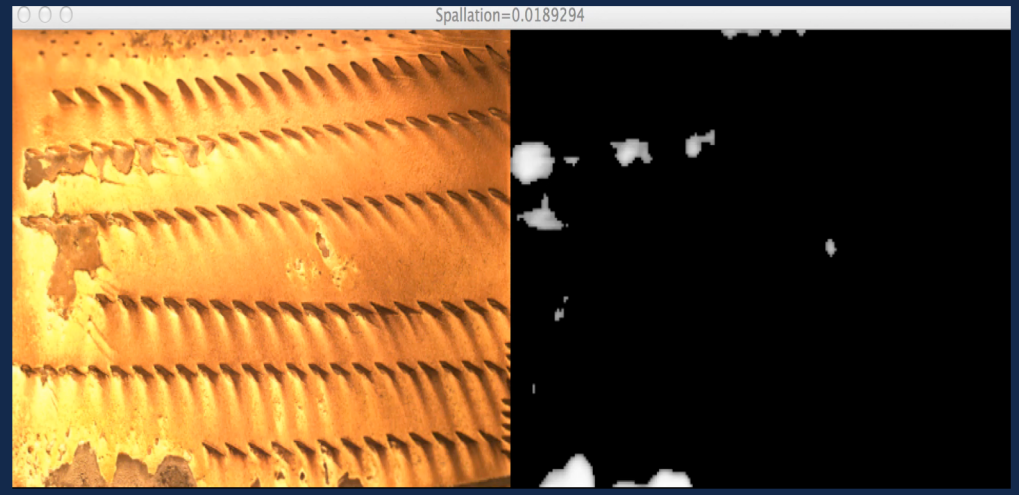
TB COATING

Digital Twin

(LIFE PREDICTION)

COATING LIFING

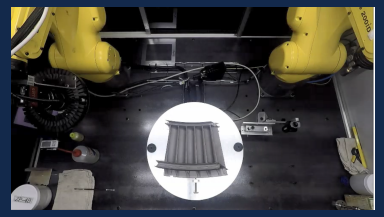
Automated distress ranking



IMPROVE DESIGN

IMPROVE TWIN

CONTINUOUS LEARNING AND DESIGN



Infinite value: Immortal machines

Engine

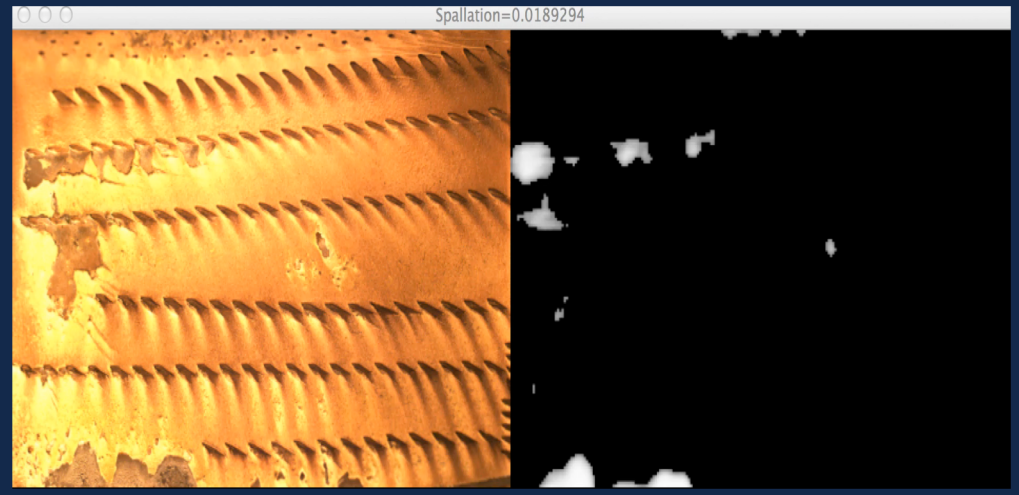
S1 BLADE

Digital Twin

(LIFE PREDICTION)

COATING LIFING

Automated distress ranking



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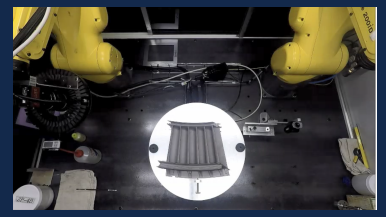
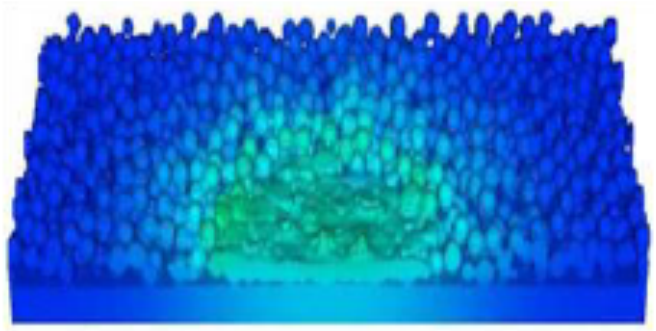


Partnering for Value: GE and the national labs

Additive metal laser spatter

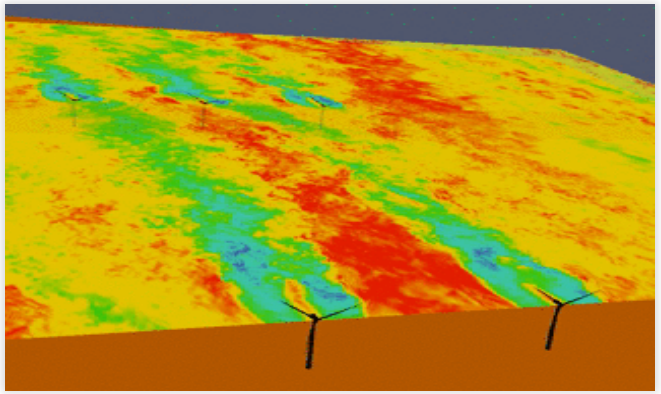


- Quartz Penguin CTS
- ALE3D + Experiment
- GE Additive

Lawrence Livermore National Laboratory

Improve 3D printing yield through process control & inspection to reduce part defects

Wind farm design optimization

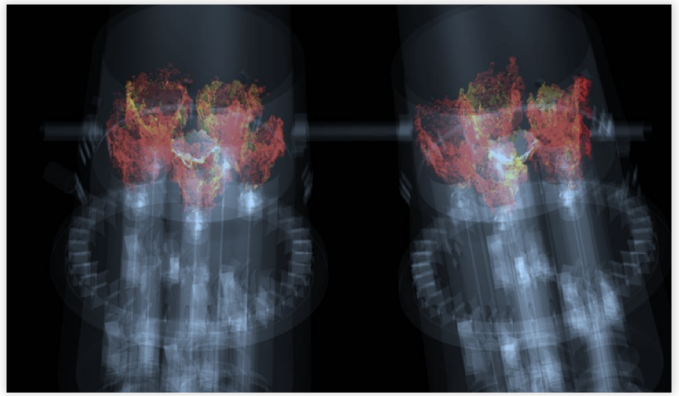


- Mira IBM Blue Gene/Q + GE Cray
- Proprietary Codes
- GE Renewables

Argonne NATIONAL LABORATORY

Optimized Wind farm design - – **5% Improvement**

CC Power plant performance

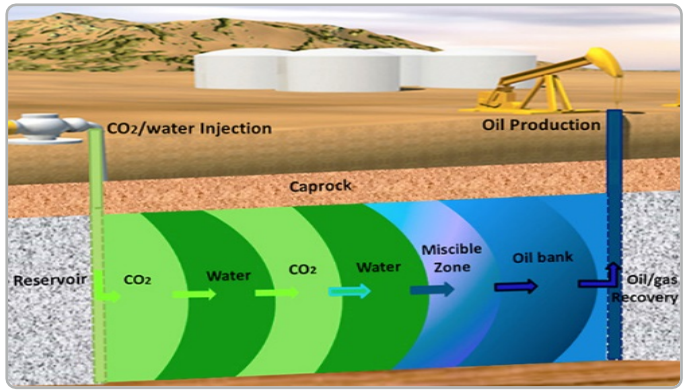


- Titan Cray XK7
- Cascade Simulation Software
- GE Power

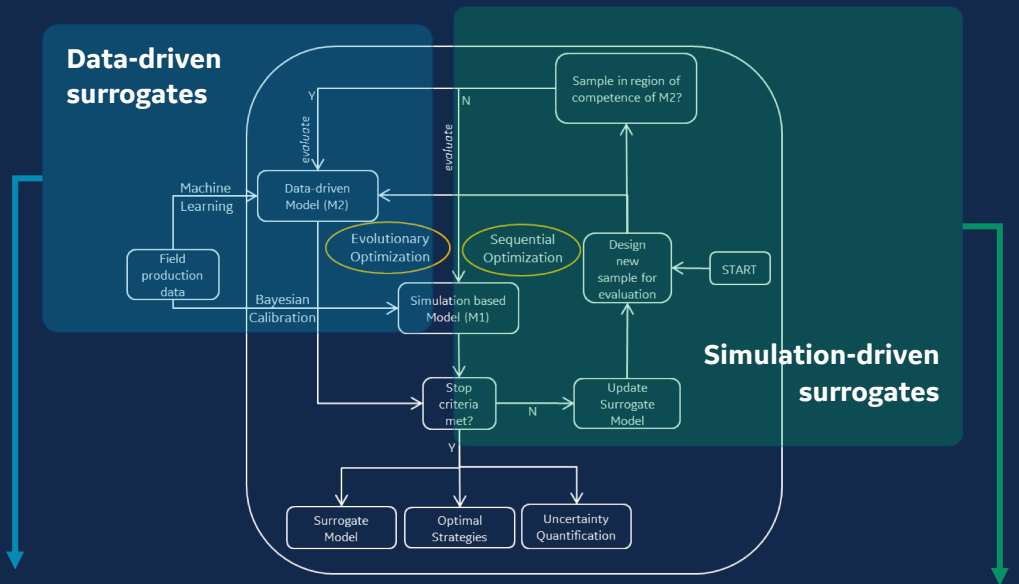
OAK RIDGE National Laboratory

Predict thermo-acoustic performance of a next-generation, power turbine - HA. **$11B in Fleet Fuel Savings over 20 years**

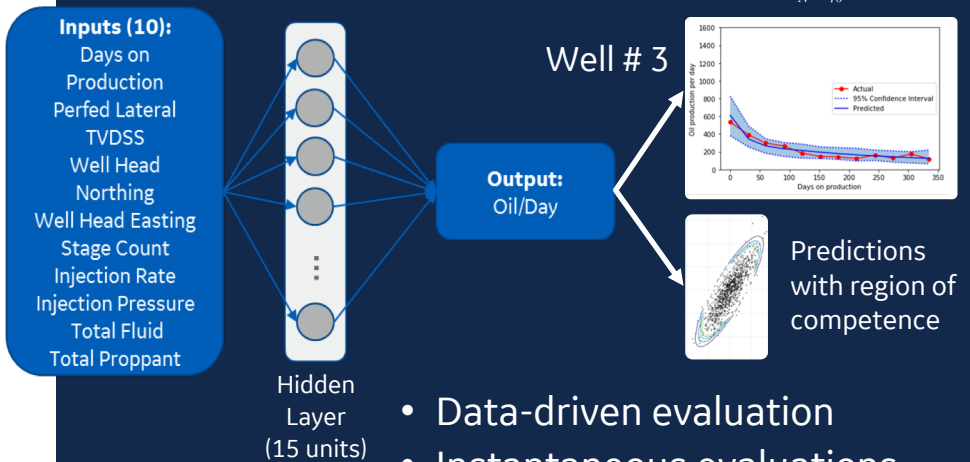
Finding new value: Gold data or high fidelity simulation



- Optimal CO_2 injection strategy for oil recovery entails expensive evaluation of high-fidelity reservoir simulator
- Reservoir time-complexity limits number of evaluations permissible; operators currently use suboptimal field-analogues

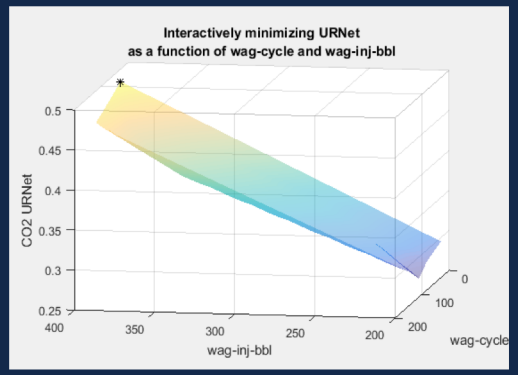


Gold data driven model



- Data-driven evaluation
- Instantaneous evaluations
- Only in regions of competence

High fidelity simulation model



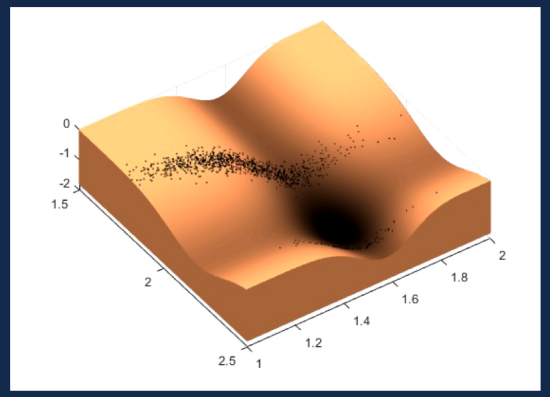
- Physics-based evaluation
- Time-complex evaluations
- Can extrapolate in input space

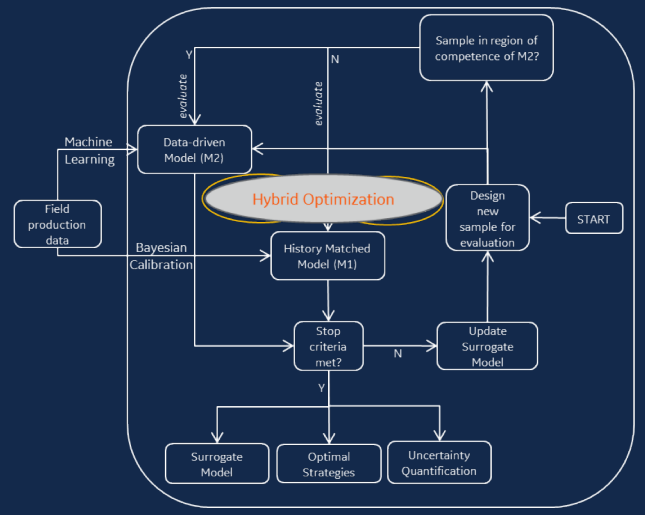
32% INCREASE IN NPV

Finding new value: Gold data and high fidelity simulation

The Hybridization problem:

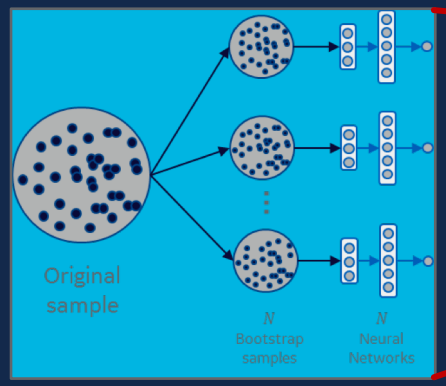
how do we use field data-driven models in conjunction with reservoir models?

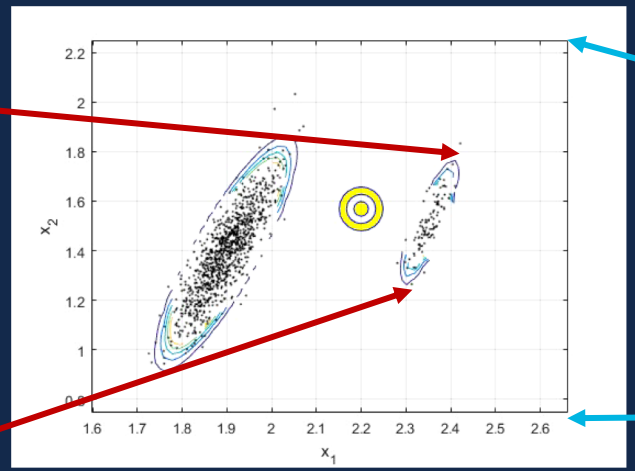




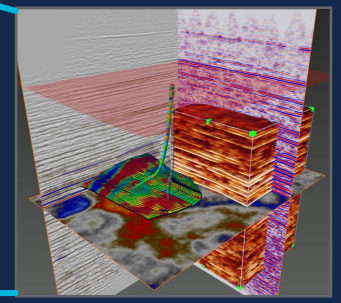
Humble AI with Active Learning

Data driven evaluations



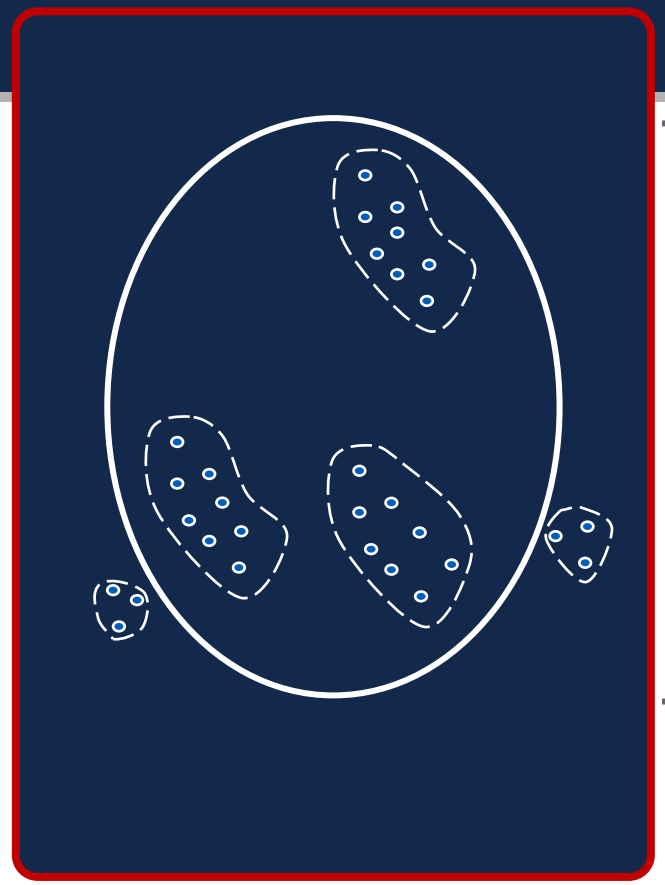


Simulation driven evaluations



OPTIMAL TRADE-OFF IN TIME-COMPLEXITY VERSUS FIDELITY OF EVALUATION AND OPTIMIZATION!

Exploring Value: Gold data + High fidelity simulation framework



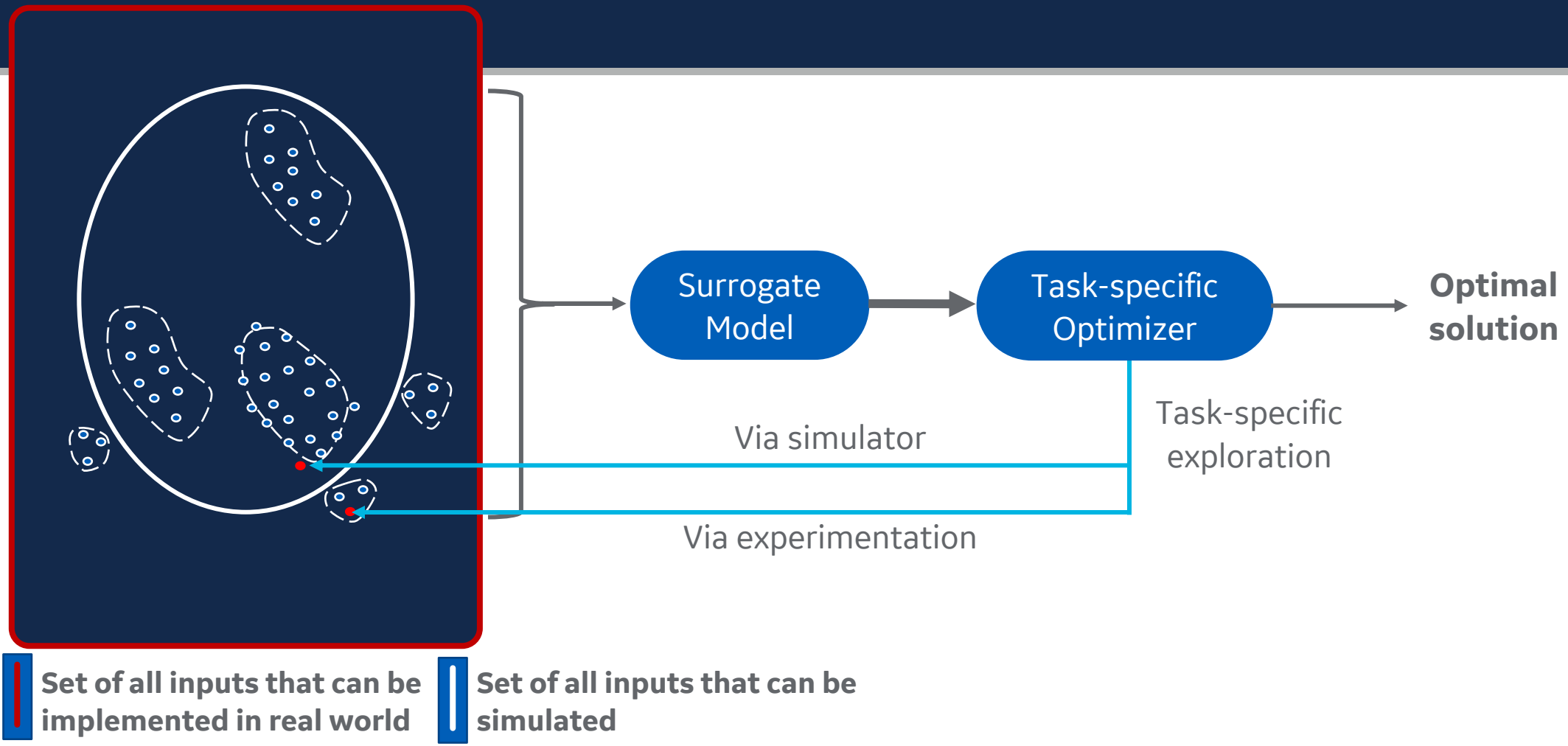
Surrogate Model → Task-specific Optimizer → **Optimal solution**

Set of all inputs that can be implemented in real world

Set of all inputs that can be simulated

Exploring Value: Gold data + High fidelity simulation framework

Continuous learning via Humble AI



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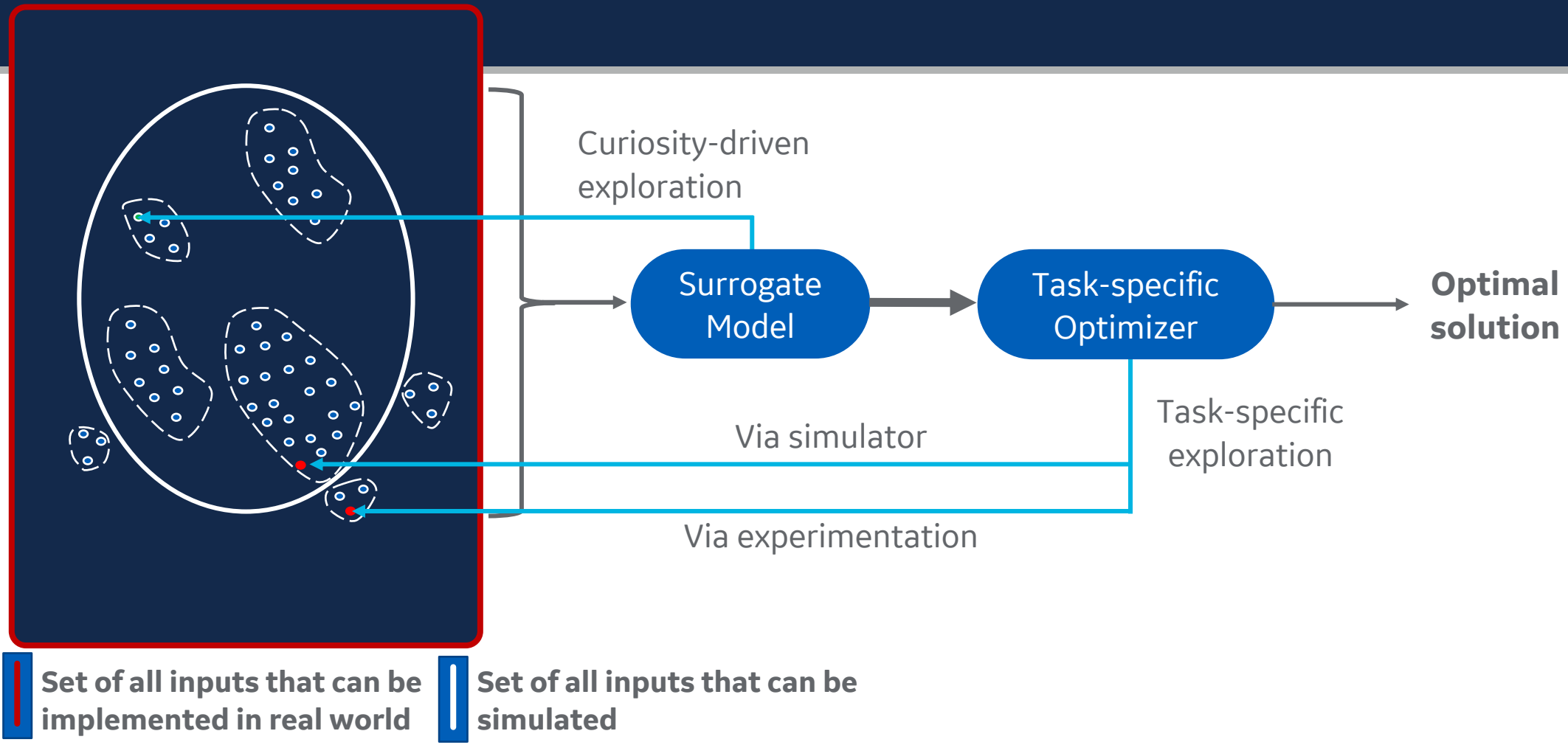

Exploring Value: Gold data + High fidelity simulation framework

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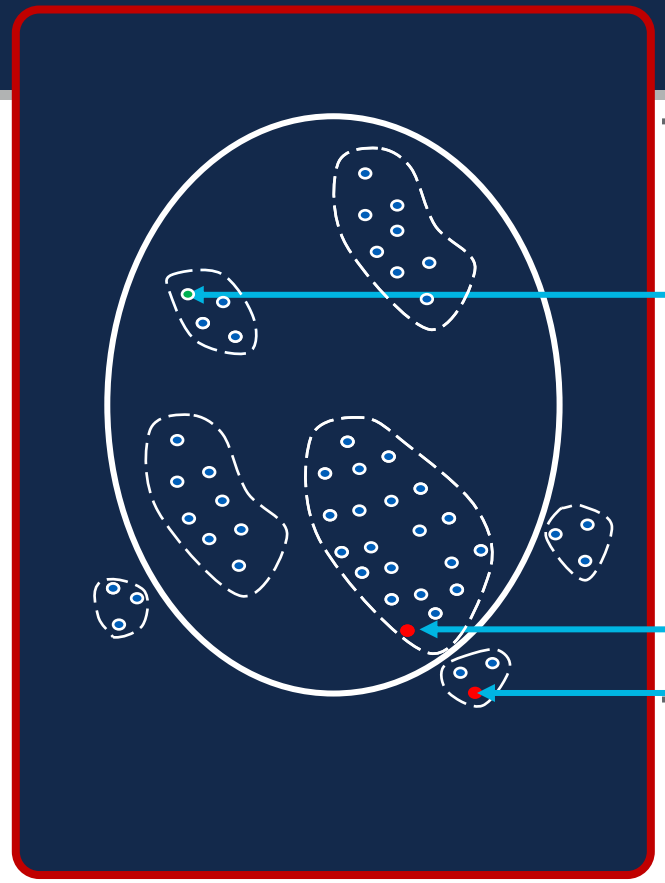


Curiosity-driven exploration

Surrogate Model

Task-specific Optimizer

Optimal solution

Task-specific exploration

Via simulator

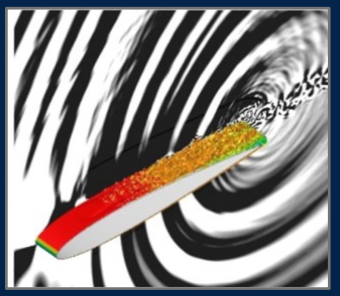
Via experimentation

Set of all inputs that can be implemented in real world

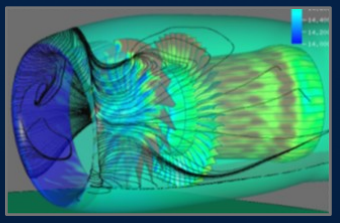
Set of all inputs that can be simulated

PROVIDE KNOWLEDGE OF MISSING REAL WORLD VARIABILITY AND PHYSICS BACK TO SIMULATOR -> INCREASE "COMPETENCE" OF SIMULATOR

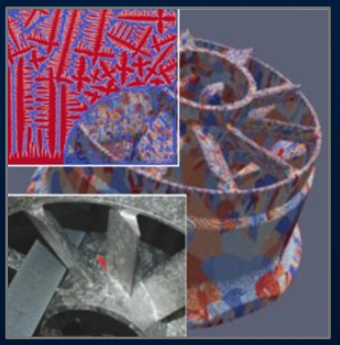
Infinite value: Immortal machines



Wind turbine blade acoustics



Inlet distortion flow



Mulitscale modeling of manufacturing & materials